Programme on Energy, Environment, Resources, and Sustainability (PEERS)

Final Project Report

Wastewater Recycling in Petroleum Industry

Submitted by

B. Saha

February 1997

Tata Energy Research Institute, New Delhi

In collaboration with:
United Nations University, Tokyo

Center for Energy and Environmental Policy
University of Delaware, U S A

and with support from
European Commission (SYNERGY Programme)

Contents

Page No.

1.0 Executivesummary 1
2.0 Introduction 2
3.0 Scope & Objectives 2
4.0 Current Path of Unsustainability 2
5.0 Methodology 3
6.0 Data Analysis 3
7.0 Current Problem of Reusing Effluent 4
8.0 Tertiary Treatment 5
9.0 Recommendation 8
10.0 Conclusions 8
11.0 Referrences 10

Waste water recycling in petroleum industry

Executive summary

The availability of fresh water reserves have been reduced mainly due to the polluted surface and ground water reserves, Government have called for more stringent environmental quality standards. Therefore, industries must adopt advanced water treatment processes so as to recycle the water protect aquatic resources.

Statement of the problem

This project examines the case of wastewater treatment & recycling in a Refinery and Petrochemicals Unit. Petroleum industry uses water for process cooling and other requirements. So far, the effort in effluent treatment has been to remove the undesirable constituents from the wastewater so that the final effluent meets the standards laid down by the Pollution Control Boards. At present, water required by the industry are met by underground source. In the recent past it has been experienced that water table is going down. Therefore it has been necessary to install a tertiary treatment plant with the view of recycling the effluent water in the cooling tower. This will reduce the fresh water consumption and will also reduce the polluted water discharge to the river.

Technology for treatment of effluent water for recycling

There are a number of technologies available for treating the effluent for the purpose of reusing. At present wastewater from all unit processes are collected in a sump and then treated in Tilted plate interceptor, Dissolved air floatation, Activated sludge, Aerator and Trickling filter. The final effluent after these units has high TSS , and BOD and does not meet the quality requirements of cooling water. To improve the quality of the water, flocculation, sand filtration followed by activated carbon adsorption is proposed. After the treatment, the effluent can be recycled.

Petroleum industry should install tertiary treatment facilities and recycle the effluent thereby reducing the fresh water consumption. This is important from the consideration of sustainability of the petroleum industry.

Introduction

The concept of sustainability has gained appeal and popularity amongst statesmen, policy makers and people at large both in industrialised and less developed countries in the last decade.The finite natural resources within national borders are getting depleted at ever increasing rates to keep pace with economic growth and developmental needs of societies. Efforts are nevertheless on to operationalise `sustainability' and institutionalise the process for practitioners and decision makers. International efforts are also on to carry out capacity-building exercises so as to reap benefits of its application to everyday economic and social activity.

Scope & objectives

The scope of the study is to analyse the present effluent analysis and finding out the technology required to treat the effluent water of petroleum industry for reuse.

The objectives of the study are -

- identify the current path of unsustainability.
- identify current problem of reusing effluent water.
- identify technologies for treatment/upgrading and reuse of effluent water.
- identify the critical barriers.
- recommendation.

Current path of unsustainability

Environmental degradation due to pollution is a global concern today. Opportunities to improve economic development often seem in conflict with measures to improve the environment. During the process of development, environment is getting polluted and also the resources. Consequently, the usable resources are diminishing fast and becoming scarce. World over there has been a growing awakening and concern about the environment and a re-examination of the relationship between water and environment in that context.

Indian scenario

Water was available in abundance in many parts of India and was the cheapest resource. Little attention was paid to its judicious use. As a result, water pollution has become a growing problem and not

surprisingly, most serious in the densely populated regions. While India's pollution laws spell out strict standards, pollution control enforcement has not been very strict. As a result, a number of industries/municipalities discharged their effluent into the nearest watercourse without/with inadequate treatment. This has added to the pollution loads of already polluted rivers. Conservation measures are necessary in all such affected areas for restoring the quantitative balance as well as the qualitative integrity of the water. With the availability of fresh water reserves now seriously reduced and potable water has become scarce, reputed organisations have called for more stringent effluent quality standards for conserving resources. Water conservation programs should include curative and preventive measures for protecting the quality of water in the rivers, lakes, tanks and canals. The principle as listed in the Rio Declaration on Environment and Development adopted in 1992 by the United Nations, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it. Industry being one of the major consumers of water, available fresh water for industrial use is also becoming scarce. Therefore, for sustainable development industry should aim for optimal use of water and restrict the pollutants discharge to the environment.

Methodology

Petroleum Industry uses water for various activities like cooling, process requirement,sanitary uses etc. The source of fresh water could be river,lake, underground water etc. After use of this water in the process these water goes to effluent treatment plant for primary and secondary treatment and then it is discharged to the nearby channel/river. This work will concentrate on an existing refinery wastewater treatment facilities and problems of recycling and reuse of this treated water and further treatment required for recycling of this water.

Data analysis

Here, we consider the case of a Petroleum Industry crude both oil refining and downstream units are there. In the refining sector Crude Distillation unit, Kerosene Treating Unit, Delayed Coking Unit and Coke Calcination Units are there. Petrochemicals unit consists of Xylenes Unit, Dimethyl Terephthalate Unit and Polyester Staple Fibre Unit. Apart from these a captive power generating unit is there. The total requirement of water in these various units are 900 m3/hr. The requirement of water in these units is met through ground water. At present about 400 cubic meter of water is used for cooling water make-up requirement and 500 cubic meter used for different process requirement in various units, boiler feed water, fire water, and sanitary requirement etc. Water after use in the process units is send

to the effluent treatment unit before discharging it to nearby channel. The total generation of wastewater is about 425 m3/hr. At present primary and secondary treatment facilities are available for treatment of this wastewater before discharging it to nearby river after meeting the statutory quality requirement. If the effluent can be treated further and reused, the fresh water requirement will reduce by about 44%. In addition to reduction of the consumption of fresh water, polluted water discharged from the effluent treatment plant to outside will stop totally. The recycled amount will meet almost the total cooling water make-up requirement of the complex.

Current problem of reusing effluent water

There are two separate wastewater treatment plant for refinery and petrochemicals units. At present wastewater from various unit is first collected in catch pit/sump tank. Oil in the water is separated first by API separator and then by TPI(Tilted Plate Intercepter). The pH of the water is then controlled at 7.0 - 8.0 by using acids or alkali. After that water is sent to Dissolved Air Floatation unit where oil and suspended solids are removed. Polyelectrolyte is used for better separation. The water is then send to Activated Sludge Unit where BOD of water is reduced with the microbial action. The water then goes to aerated tank and then to trickling filter where BOD is further improved by biological mass. The water then goes to Waste Stabilisation Pond where natural aquatic processes of bacterial and algal symbiosis takes place in sunlight. The treated effluent from the primary and secondary processes is then discharged separately to the nearby channel. The discharged water does not have the quality required for recycle and reuse in the cooling tower. Parameters like Oil & Grease, BOD, Total Dissolved Solids and Silica are normally higher in the effluent, after primary and secondary treatment. A typical characteristics of treated water in primary and secondary processes is given in Table 1.

Table 1 Typical Characteristics of treated effluent after primary and secondary processes

Parameter	Unit	Quantity
Flow Rate	m3/hr	400
pH	-	7.5 - 8.5
Oil & Grease	mg/lt	10.0
BOD	mg/lt	40.0
TSS	mg/lt	50.0
Silica	mg/lt	40.0

The water available after primary and secondary treatment do not meet the specification of cooling water make-up. Therefore, it cannot be recycled directly to the cooling tower for reuse. The characteristics of cooling water make-up are given in Table 2.

Table 2 Cooling Water Make-up Characteristics

Parameter	Unit	Quantity
pH	-	6.5 - 7.0
Oil & Grease	mg/lt	less than 3.0
BOD	mg/lt	less than 15.0
TSS	mg/lt	less than 10.0
Silica	mg/lt	less than 20.0

As would be seen from the above, the quality of the water should have to be improved by further treatment for reusing. It has been decided to install Tertiary Treatment facilities, so that the treated water can be reused in the process again and thereby reducing the total fresh water requirement by about 44%.

Process for treatment/upgrading and reuse of effluent water

The effluent can be treated by Tertiary treatment to improve the quality for using as a cooling warer make-up.

Tertiary treatment

Flash mixer

In the flash mixer, clear water from the clear water pond is mixed with 10% sodium carbonate and 10% lime solution for softening of water. A retention time of about 3.0 minute would be maintained in the flash mixer for proper mixing of the chemicals with water. The nominal capacity of the fash mixer is 15.4 cubic meter and the shape of the vessel would be circular with a diameter of 2.8 meter and height of about 6.1 meter. In the flash mixer an agitator will be used for mixing of the solution and it will rotate at a rpm of 100. The materials of construction of the mixer is RCC with epoxy coating to

handle the alkaline solution for preventing corrosion.The materials of construction of the agitator would be SS-304.

Sludge clarifier

A sludge blanket clarifier includes both flocculation & clarification. Both the function are performed in a single unit in different zones. In the blanket clarifier flocs are formed in the presence of flocculaing agent. A vertical flow is induced from the bottom and decanted water is skimmed out from the top. For floc build-up, inlet and sludge zones are in close contact and the flocculation zone is occupied in part or as a whole by a blanket of flocs. Rising flocs comes into contact wth both the settling flocs and the stationary blanket of flocs which is in equilibrium with the hydraulic environment. Agglomertion of flocs thus takes place by direct contact. The bottom section is diverted to mixing of incoming water with chemicals. All chemical reactions occur in the blanket so that the newly formed insoluble salts precipitate directly on the sludge particles already present. The clarification zone extends from the top of the sludge blanket to the surface of the liquid. Upon emergence from the sludge blanket, the water passes through this clarification zone and is collected for use. The influent will have about 300-400 mg/litre of solid concentration and the effluent will have 20-30 mg/litre solid concentration. A mechanical scrapper arm with speed 1/30 rpm will scrap out the solids deposited at the bottom. The incoming flow rate of water will be 400 cubic meter and the detention of water in the sludge blanket clarifier will be 2.62 hours. The materials of construction of the sludge clarifier is RCC with epoxy coating.

pH adjustment tank

The clarified water from the sludge blanket clarifier will then flows to the pH adjustment tank of rectangular size. The clarified water will have pH in the range of 10-11. Sulfuric acid of 10% strength will be added to adjust its pH to about 6.5 - 7.0. In the pH adjustment tank, a turbine type agitator will rotate at an rpm of 100 and a residense time of 15 minutes will ensure proper mixing. The materials of construction of the tank will be RCC with epoxy coating and the agitator materials of construction will be SS304.

Filtration

Filtration process is used to remove further the organic material which are in the suspended or colloidal form. Normally pressure sand filter is used as filtering medium. The sand filter comprises of a bed of sand serving as a single medium granular matrix supported on gravel overlying an underdrainage system. Water containing suspended matter will be pumped to the top of filter bed, suspended nd coloidal solids will be left behind in the granular medium matrix. Accumulation of suspended particles in the pores and to the surface of the filter medium leads to the head loss as pore volume is reduced and greater resistance is offered o the flow of water. The maximum allowable pressure across the bed will be 1.0 kg/cm2. The effective sand size to be used as filtering media will be 0.55 mm with an uniformity coefficient of 1.3-1.8. The diameter of the filtering medium will be 3.65 meter and the height of the filtering medium will be 600mm. The size of the gravel will be 3-12 mm and the depth of the gravel bed will be 400mm. The hydraulic loading of the filter will be 12.0 m3/m2/hr. The inlet water from the clarifier will have solid concentration of 20-30 mg/lt ofsolid concentration and the water from the sand filter will have 8-12 mg/lt of solid concentration.

Carbon adsorption

Activated carbon treatment of wastewater is usually thought of as a polishing process for water that has already received normal biological treatment. A fixed-bed column is used as means of contacting wastewater with granular carbon. The water will be applied from the top of the bed and withdrawn from the bottom. The carbon will be held in place with an underdrain system at the bottom of the column. In the carbon adsorption process, residual organic material will be adsorbed in the porous structure of the carbon granules by physical adsorption method there by removing those material from the water. This process helps in improving BOD of the water. The depth of the activated carbon bed will be 900 mm and the size of activated carbon will be 0.8-1.6 mm with an uniformity coefficient of 1.2-1.6. The supporting media will be gravel of size 3-12 mm. A maximum pressure drop of 1.0 kg/cm2 will be maintained across the bed. After a head loss of 1.0 kg/m2 backwashing will be done by air scouring for a duration of 2-3 minutes. After that backwashing with treated water will be done and the flowrate of backwash water will be 325 cubic meter/hr.

Sludge dewatering

The sludge from the sludge clarifier will be centrifuged to remove water. The sludge from the sludge blanket clarifier bottom will be pumped to the centrifuge. The centrifuge dewaters the sludge from a consistency of about 2.0% solids in the feed to about 20% solids at the outlet. The dewatered cake will then be used for landfilling. The separated water will be recycled back to the system for treatment. The materials of construction of the centrifuge will be SS-304.

The water will be recycled to the cooling tower as make-up. The treated water will meet the quality requirement of cooling water make-up.

Status of the project

The contract has been finalised with M/s Thermax Limited for installation of the Tertiary Treatment Plant on turnkey basis. M/s Thermax Limited will do the designing, detail engineering, supplying and construction of the equipments for the project. The construction work has already been started and is expected to be commissioned in the next financial year.

Recommendations

Industry is using fresh water from the sources like surface water or ground water and as the fresh water availability is becoming difficult, therefore industry should try to reduce the consumption of fresh water and at the same time improve on the effluent quality. Reduction in fresh water consumption in industry will therefore call for installation of tertiary treatment facilities This is very important from the consideration of sustainability of the industry. Normally industry do not want to install tertiary treatment facilities as it involves huge expenditure and water is available at negligible cost. But if the present trend continues, water will no more be available easily. Therefore it would be wise for petroleum industry to go for tertiary treatment of effluent water and recycle it from the consideration of sustainability.

Conclusions

In an area of hightened environmental awareness, growing competition for limited water resources and a desire for cleaner water cherished by all, there is an ever-increasing need for resource conservation and abatement of pollution. Industrial effluents control is very important from the consideration of

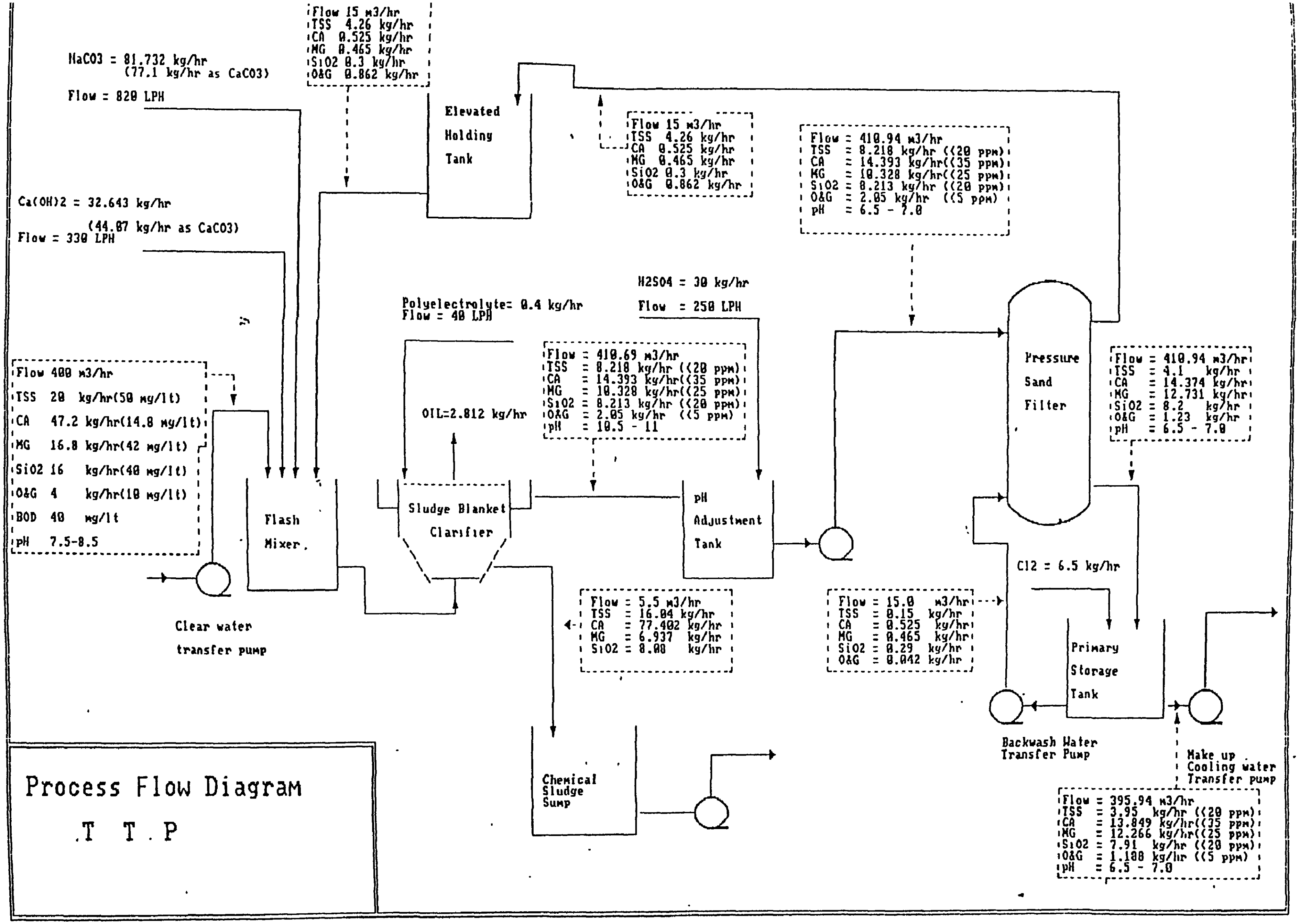
sustainability. As surface water is getting polluted by industrial, municipal and other wastes, ground water is the other source which will be under stress now. It is therefore necessary that

- petroleum industry should aim for zero discharge of effluents to reduce the water pollution of the rivers/lakes etc., and
- reduce fresh water consumption for industrial use.

In order to achieve this, regulatory bodies need to be active & insist industries to go for tertiary treatment and reuse effluent water with an idea of conserving fresh water and reducing surface water pollution.

References :

1. Groundwater Quality In Problem Areas : A Status Report - CPCB
2. National Water Policy-Government of India - Bhagirath
3. "Water-1995" - Dr. M.A.Chitale
4. Waste Water Engineering : Treatment, Disposal And Reuse - George Tchobanoglous and Franklin Burton
5. Principles of Industrial Waste Treatment - Gurnham
6. Water and Wastewater Technology - Mark J, Hammer
7. Pollution Control In Petroleum Refinery and Petrochemical Industries - Hardam Singh Azad
8. Ericology, Vol II, No 7, December 1996
9. Indian J. Environmental Protection, Vol 16, October 1996.
10. Wastewater Engineering-reatment,Disposal,Reuse-Metcalf & Eddy
11. Manual on water supply & treatment - Central public health & environmental engineering organisation



Process Flow Diagram

T T P